

How material culture extends the mind: mental time-travel and the invention of the calendar

Helen De Cruz (hdecruz@vub.ac.be)

Centre for Logic and Philosophy of Science – Free University of Brussels; Pleinlaan 2
1050 Brussels, Belgium

Johan De Smedt (Johan.DeSmedt@UGent.be)

Department of Philosophy and Moral Science – Ghent University; Blandijnberg 2
9000 Ghent, Belgium

Abstract

The extended mind thesis proposes that humans are capable of advanced cognition, not mainly through radical structural changes in the brain, but through their ability to delegate cognitive tasks to the external world. It views material culture as an important causal factor in human cognitive evolution. Here, we explore this hypothesis through an analysis of Upper Palaeolithic forms of material culture which have been interpreted as artificial memory systems. We argue that material calendrical systems complement evolved internal time representations, because they enable humans to project past events into the future more accurately than is possible with episodic memory alone, which greatly improves foraging strategies. Thus, the earliest calendars can be seen as a material extension of the human mind's evolved cognitive abilities.

Introduction

Ever since Darwin, comparative psychologists have considered the problem of the apparent mental discontinuity between humans and other animals. Why are humans, more so than other animals, capable of advanced, representation-hungry cognition? The extended mind thesis (e.g., Clark & Chalmers, 1998) suggests that what is distinctive about the human brain is how its structure is supplemented by material culture. Humans rely heavily on environmental support such as books, electronically stored documents, nautical slide rulers, or simply pen and paper to delegate computational problems to the external world. These instances are a two-way interaction, in which humans and external aids constitute a coupled cognitive system. It is this system as a whole that produces the cognitive output. Therefore, when the external part is removed, behavioural competence will drop. For instance, when a Scrabble player is allowed to physically re-arrange the tiles on her tray, performance is significantly better than when she is forced to re-arrange the tiles mentally. In a very real sense then, this re-arranging of tiles is an integral part of problem solving itself.

There have been several attempts to characterize the role of external media in human cognitive evolution. Donald (1991) views the evolution of human cognition as stages in which new memory representations emerged; the final stage is marked by the use of material culture as external memory system. According to Mithen (2000), the Upper Palaeolithic symbolic revolution, the sudden

appearance of art, symbolic storage and a wide variety of specialized technologies starting 45,000 BP (before present), marks the extension of the mind beyond the brain. Material culture can serve as an anchor for counterintuitive concepts like religious ideas that have 'no natural home within the mind' (Mithen, 2000, 214). Gods typically behave according to a belief-desire psychology, which should enable us to interact with them using our theory of mind. However, because gods are not really there, interaction with them is difficult. Only when gods are made tangible and visible, in the shape of masks or icons, it becomes possible to use basic social cognitive skills in this domain (Day, 2004). Because of its endurance, material culture can extend cognition in several ways, the most obvious as a non-biological memory. Visual art and written documents enable us to store information beyond the scope of the individual memory and to reliably transmit it across generations. Furthermore, material culture can improve cognitive performance by enhancing conceptual stability. The cultural evolution of positive integers, for example, requires material anchors such as body-parts or tallies to develop a one-to-one correspondence between countable objects and a stably ordered counting list (De Cruz, 2006). Extending the mind through material culture constitutes an epistemic action (Kirsh, 1996): it makes the world more cognitively congenial without actually altering it physically.

By exclusively focusing on art and religion, cognitive archaeologists have not yet probed how material culture was used in epistemic contexts where it causes effects in the real world, such as improving foraging success. Calendars provide an interesting case-study as they do not physically alter the environment (e.g., increasing the number of potential prey in the territory), but render it more cognitively congenial (e.g., enhancing hunting success by predicting migration events). This paper's aim is to examine the epistemic role of material culture by specifying how it can supplement evolved human cognitive abilities. We take the invention of calendrical notation-systems in the Upper Palaeolithic as a case-study, arguing that calendars extend evolved cognitive abilities by allowing humans to accurately predict cyclically occurring events. Human time processing abilities are unable to recognize cyclicity in the environment whereas a coupled cognitive system, consisting of a calendar and an interpreting human can. First, we look at evolved cog-

nitive mechanisms for keeping track of time, focusing on mental time-travel. Next, anthropological examples will illustrate how humans supplement these evolved mechanisms with material anchors. We then argue that the extension of episodic memory by material culture dates back to the Upper Palaeolithic, and illustrate this with examples of material culture interpreted by archaeologists as calendars. We conclude with a general discussion of the role of material culture in human cognitive evolution, evaluating the extended mind thesis in the light of these results.

Cognitive processes underlying the perception of time

Salient systems of time-processing

The natural world is filled with temporal regularities, which animal brains are adapted to exploit. Timing enables animals to anticipate opportunities and risks, which greatly improves their chances of survival. Two timing mechanisms are salient in a wide variety of species. To learn associations to events with particular times of day, organisms use their circadian clock, internally generated 24-hour oscillations in the suprachiasmatic nucleus (Antle & Silver, 2005). For shorter durations ranging from a few seconds to a few hours, animals rely on interval timing, which enables them to optimize their foraging behaviour in terms of time and energy costs (Bateson, 2003).

Circadian and interval timing are not the only timing mechanisms available to animals. Some species have highly specialized abilities that keep track of longer spans of time. For example, male house mice kill any neonate in their territory, except when they have mated 18 to 22 days before. During this period, where the possibility exists that the neonate is their offspring, they switch to nurturing behaviour. This hormonal mechanism enables house mice to detect relationships between events widely distributed in space and time, which could never be detected through associative learning alone (Kummer, 1995). Given that animals keep track of time through both widespread and specialized mechanisms, it seems useful to investigate whether humans possess derived cognitive mechanisms for dealing with time.

Episodic memory and mental time-travel

Within neuropsychology Tulving's hypothesis that human memory is composed of at least two functionally distinct systems, semantic and episodic memory (see Tulving, 2002, for an overview) has gained a firm foothold. Semantic memory can be broadly defined as our factual knowledge of the world (e.g., the Parthenon is in Athens). It does not refer in any way to personal experience. Episodic memory, on the other hand, allows us to remember personally experienced events and to travel back in time to re-experience those events (e.g., last summer I went to Athens and visited the Parthenon). It is oriented towards the past, whereas semantic memories are oriented towards the present. A rat using its semantic memory to avoid a food-type it remembers as

noxious need not think back to earlier experiences involving this food. Indeed, learning as a rule does not require episodic memory. This was demonstrated by a case study of three amnesiac patients with early focal pathology in the hippocampus (Vargha-Khadem et al., 1997). Remarkably, despite their inability to remember personal experiences, all three achieved near normal levels of language competence and factual knowledge, and even attended mainstream schools.

The ability for mental time-travel and episodic memory develop *in tandem* during cognitive development, suggesting that it is episodic memory which allows us to simulate future experiences. Episodic future thinking (Atance & O'Neill, 2001) enables humans to foresee possible future consequences of their current behaviour, or to make preparations in anticipation of a planned activity. Episodic memory arises gradually in human development, long after semantic memory is in place, as is illustrated by infantile amnesia, which persists until three to five years of age (Perner & Ruffman, 1995). The ability to travel mentally into the future follows a similar developmental trajectory: given the choice between a small immediate reward and a larger delayed reward, only children of four years and older forego immediate gratification and choose the delayed one (Thompson, Barresi & Moore, 1997).

Mental time-travel in an evolutionary context

Since Suddendorf and Corballis (1997) have suggested that only humans travel mentally in time, comparative psychologists have investigated whether nonhuman animals are able to remember consciously experienced events and imagine the future. To date, the strongest candidate for episodic-like memory in nonhuman animals is the food-caching scrub jay, *Aphelocoma californica* (Clayton & Dickinson, 1998): the birds' recoveries of previously stored food-items show sensitivity to what was cached where and when. For most other studies of episodic recall in animals, including primates, alternative non-episodic accounts such as familiarity can be offered (Roberts, 2002). Why is evidence for mental time-travel in nonhuman animals mostly lacking, seen its apparent benefits in food-caching and foraging? As most animal learning does not require episodic memory, its benefits must outweigh the costs of altering pre-existing neural structures to accommodate it. Episodic memory, however, tends to be less accurate than semantic memory. Numerous laboratory experiments (e.g., Marsh & Tversky, 2004) show that episodic memories, however vivid and confident, are vulnerable to distortion. Retelling personal recollections involves exaggerations, omissions, and simplifications to entertain or help the audience better understand. Under controlled experimental conditions, biased retellings of events alter the memories one has of the event (Tversky & Marsh, 2000); they routinely become part of one's own episodic recall, replacing more accurate memories. These shortcomings make episodic memory particularly unfit to recognize cyclical seasonal events. How can a hunter-gatherer remember

when to return to a specific berry-tree in the groups' territory where she has fortuitously encountered an abundant supply of berries some months ago? Farmers need even more precise information on when to plant or harvest what type of crop. As distorted retellings corrode episodic memories, sharing these reminiscences with a wider audience clearly does not increase their reliability. This experimental evidence speaks against Caspari and Lee (2004), who explain the Upper Palaeolithic symbolic revolution as a consequence of increased human longevity. They argue that intensified oral intergenerational transmission of complex cultural information may have contributed to the innovations associated with behavioural modernity. Seeing that episodic memories are susceptible to distortion through retelling, distributing cognition through communication does not increase conceptual stability. On the other hand, extending the mind by means of material objects may prove more fruitful, as it protects episodic memories from misrepresentation.

Material anchors and epistemic artefacts

In disparate cultures, people keep track of cyclical events by extending their evolved internal timing mechanisms into the world by using cyclical natural events as material anchors. Horticulturalists from the Torres Islands, Vanuatu (Melanesia) traditionally calibrate their lunar calendar to seasonal events. The appearance of a ubiquitous sea-worm, *palolo*, in October, marks the planting of yam and other garden crops. The metamorphosis of a local species of ant into its winged phase, *vūhoro*, in January serves as a marker for the end of the planting cycle (Mondragón, 2004). Material anchors need not be restricted to the visual modality. The Andaman Islanders knew a calendar of scents: the distinct succession of odours in the densely covered jungles was used to mark different periods of the year (Radcliffe-Brown, 1922). In both cases, a mental representation of cyclic activities (e.g., yearly cycle of planting, weeding and harvesting) is rendered more stable and reliable by tying it to seasonal occurrences in nature.

Elsewhere, humans draw on calendars, especially designed artefacts to keep track of cyclical events. The Mandan (a Native American Great Plains culture) recorded lunar phases as rows of crescents onto sheets of paper. Some of these are accompanied by plant symbols, indicating a record of planting and harvesting (Thornton, 2003). Artefacts have the advantage that they are less constrained by processes in nature, thereby further enhancing the stability of the representation of cyclical events. In Chankillo, Peru, a calendar (2300 BP) consisting of 13 aligned towers was calibrated to the winter and summer solstices. The towers and gaps in between enabled tracking the progress of the Sun to within an accuracy of 2 or 3 days, which was vital for agriculture in this arid region (Ghezzi & Ruggles, 2007). Sterelny (2004) has termed artefacts exclusively made to serve epistemic purposes *epistemic artefacts*. They are a distinctive feature of human cognition. Nonhuman animals sometimes use objects for purely epistemic purposes, such as the female gorilla observed by Breuer, Ndoundou-Hockemba

and Fishlock (2005), which probed the depth of a pool with a stick before deciding to cross it. To our knowledge, however, no animal has been observed to make tools exclusively for epistemic purposes.

Evidence for the extended mind in the archaeological record

The earliest archaeological evidence for epistemic artefacts in the form of art and incised bones dates back to the early Upper Palaeolithic at around 45,000 BP. Here, we discuss both direct and indirect evidence that strongly suggests that calendars were invented during this period, and that they had a significant impact on human foraging success.

Incised bone and antler objects

Upper Palaeolithic bone and antler objects with regular incisions have been recovered since the 1860s. The fact that they have ordered sets of notches or incisions indicates that these artefacts were used to represent numerical information. Marshack (1972) proposed the influential hypothesis that many of these objects were lunar calendars. His conclusion that notched bones represent the first human notation systems has gained general acceptance in the cognitive archaeological community. Based on microscopic analysis, d'Errico (1998) has subsequently developed both a theoretical framework and an explicit methodology for evaluating the use of incised bone objects. When morphologically resembling stone points were used and abandoned subsequently, the accumulation of the engravings was probably gradual, similar to a tally-stick. If, in contrast, morphologically distinct burins were used simultaneously, we can infer that the artefact was conceived as a whole, representing different items with different symbols, like a calendar. The code for the symbols is lost, as we do not have enough information about these prehistoric societies to find out what they mean. From ethnographic parallels however plausible functions of these objects can be inferred.

To take but one example: the Taï plaque from the Taï cave (Aquitaine, France) dates to the end of the last Ice Age (about 10,000 BP). It is engraved with long horizontal lines, each marked with hundreds of small, vertical notches. According to Marshack (1991), this plaque represents a lunar calendar—an interpretation supported by its resemblance to ethnographic examples, such as the stick-calendar (Figure 1) used by the Yakut, a sub-arctic Siberian culture subsisting on hunting, gathering and herding reindeer. The latter shows two months along each edge, incised with day units. Several days bear signs to mark seasonal events (e.g., the flowering of certain plants), astronomical observations (e.g., the appearance of the Pleiades, important in their shamanistic rituals), as well as Christian (Orthodox) holidays.

Rock art

Many scholars (e.g., Mithen, 1988) agree that Palaeolithic art has served as artificial memory system for ecologically relevant information. Rock art often emphasizes information useful to hunters, such as the ex-

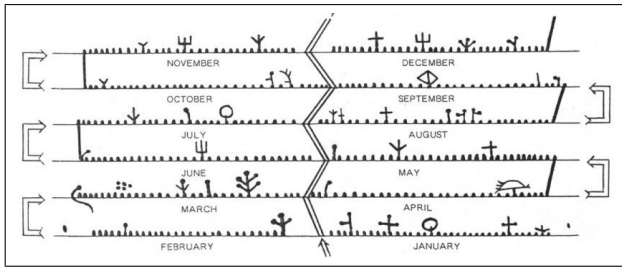


Figure 1: Schematic representation of Yakut stick calendar. Reprinted, with permission, from Marshack (1991), p. 32, Fig. 6.

aggerated representation of fat deposits on horses and aurochs, or the depiction of footprints of prey species in lieu of hoofs. Water birds and sea-mammals are often depicted in prehistoric art. The rarity of these animals in the Palaeolithic diet and their use as temporal cues by contemporary hunter-gatherers suggest that their representation served as an external storage of cues for seasonal changes. In historical times, the mating behaviour of geese, ducks and sea mammals served as cues for seasonal changes to Northwest Coast Native Americans and Inuit.

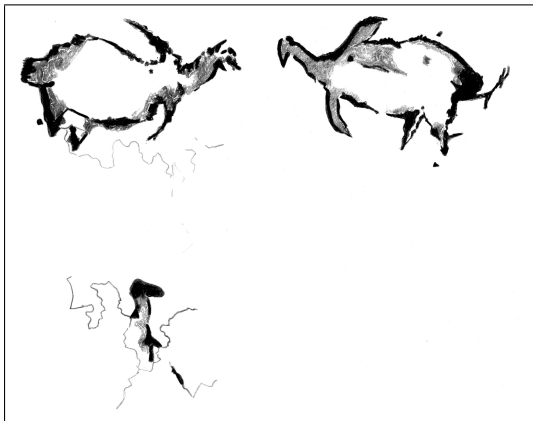


Figure 2: Scene depicting three auks at the Cosquer cave (Bouches-du-Rhône, France).

D'Errico's (1994) detailed analysis of a scene depicting three birds identified as great auks (*Pinguinus impennis*) at the Cosquer cave (Figure 2), dated at about 27,000 years ago, supports this interpretation. These large, flightless, now-extinct birds seasonally flocked to form large breeding colonies on offshore islands. This behaviour was seasonally restricted to May-June, when mating occurred, eggs were hatched and chicks raised. The conspicuousness of large breeding colonies on nearby islands may have been useful for prehistoric hunter-gatherers as a material anchor for seasonal events related to the beginning of summer. The scene shows three individuals, two facing each other with wings outspread, and a third, lying down with wings folded. As in all *Alcidae*, the great auk's wings were useless for flight; they were only

used during swimming or in combat for mates, when they were vigorously flapped. This opposing pair could be interpreted as males in combat, the third as a female they are disputing. Paintings depicting this mating behaviour may have served as artificial memory systems to remember and communicate their significance as a temporal marker.

Improved foraging techniques

How does the use of epistemic artefacts extend human cognition? Middle Palaeolithic (MP) hominids hunted and gathered less efficiently than Upper Palaeolithic (UP) hominids. Take the transition from MP to UP in the Southern Russian plains. In marked contrast to the earlier (MP) occupations, later (UP) sites show fewer species of prey and less variability in the concentration of fossil bones across seasons. This is taken as evidence for higher selectivity in the choice of prey and time of occupation, indicating specialized hunting and seasonal occupation of sites tuned to animal migrations (Soffer, 1989). The failure of earlier humans to recognize or record cyclicity in their environment could explain this difference. Material culture allowed the recording of cyclical patterns, enabling hunter-gatherers to time their visits to sites according to patterns in animal migration and plant growth.

The capture of Cape fur seals (*Arctocephalus pusillus*) in south-western African coastal sites presents a pertinent case-study (Klein, Cruz-Urbe & Skinner, 1999). Fur seals breed on offshore islands, the majority of births occurring during late November and early December. About nine months later, adult seals force their young from the rocks into sea. Large numbers of these young seals wash ashore, exhausted or dead—an ideal time for mobile hunter-gatherers to visit these sites. Fossil remains from seals in UP sites indeed mostly represent individuals of about nine months old, implying that UP people timed their visits to the coast to fall within the August-October peak in juvenile seal availability. In contrast, MP sites do not show such a fixed pattern. The bones of seals recovered from these sites are commonly older, ranging from sub-adults to adults, not showing any cyclicity at all, a pattern similar to that in dens of fossil hyenas.

Recognizing cyclicity not only had an impact on hunting success, but also probably resulted in a substantial broadening of the human diet. Fish bones are mostly absent in the MP archaeological record. In contrast, numerous archaeological sites indicate that UP people relied heavily on fish for their diet. They show patterns of seasonal and specialized fish exploitation. At Ishango, Congo, along the Upper Semliki River, dense concentrations of fish remains, together with hundreds of barbed points used to spear the fish, dated at about 25 000 BP have been recovered (Stewart, 1994). More than 30 % of these remains belong to the genus *Barbus*, a large minnow-like fish. Their size range represents primarily mature populations, probably caught on their spawning migration. This implies that the fishermen at Ishango timed their capture to the rainy season, when

large quantities of *Barbus* congregate in river mouths on their yearly spawning migration. The repeated rainy season occupations at Ishango indicate the predictability of these. Interestingly, two incised bones dating to the same period have been recovered at Ishango (Figure 3). The spatial distribution of their notches almost certainly indicates that they are artificial memory systems.

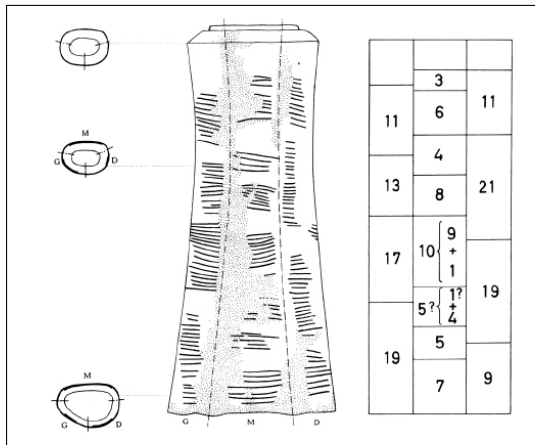


Figure 3: Notched bone from Ishango. Reprinted with permission of the Belgian Royal Museum for Natural History.

One reason why MP people neglected such a stable and abundant food source may be that the systematic exploitation of fish requires recognizing cyclical patterns of spawning and migration. In historic times, the Northwest Coast Native Americans planned and prepared for the capture of salmon months in advance. There is no reliable evidence for epistemic artefacts in the form of art or notched bones prior to the UP. Older findings are usually ambiguous. The co-occurrence of the earliest epistemic artefacts with improved foraging techniques and increased dietary breadth suggests that recognizing cyclicity in the environment requires an extended mind.

Discussion and concluding remarks

We have presented a cognitive archaeological perspective on the extended mind. Since the symbolic revolution, humans have created epistemic artefacts that make them part of distributed cognitive systems with computational capacities extending their evolved cognitive abilities. Calendars and interpreting humans constitute a coupled cognitive system that enables humans to predict cyclic events far more accurately than evolved cognitive abilities for keeping track of time allow. The archaeological evidence discussed above suggests that hominids prior to the UP were incapable of recognizing cyclicity, despite some indication of an episodic-like memory in early *Homo* starting 2.5 million years ago with the appearance of the first stone tools. The caching of these Oldowan tools for future use (Potts, 1994) can be tentatively taken as evidence for episodic future thinking. Apparently, this was not enough to allow them to predict cyclical events. Why did epistemic artefacts ap-

pear relatively late in the archaeological record at about 45,000 years ago? Possibly, new cognitive capacities such as metarepresentation enabled hominids to externally represent ideas. In the broadest sense of the term, a metarepresentation is a representation of a representation. A cave painting of a horse is the material representation of the painter's mental representation of horses. To date, there is no convincing evidence for metarepresentation in nonhuman animals, including great apes (Call & Tomasello, 1999), suggesting that it is a human cognitive specialization. Art and notched artefacts are representations that are deliberately manipulated (e.g., the exaggeration of some body parts, the grouping of notches into spatially distinct clusters), suggesting that Upper Palaeolithic people who made them possessed the ability to manipulate representations. Such manipulations require metarepresentation (see also Dennett, 2000 and Leslie, 1987).

In conclusion, the invention of calendars and other epistemic artefacts at about 45,000 years ago enabled humans to accurately time cyclical events, which greatly increased their foraging success. Some philosophers of mind (e.g., Giere, 2004) have raised criticisms against an interpretation of the extended mind where cognition actually takes place outside the brain. Calendars don't plan, humans who use them do. Therefore, the extended mind can only be properly understood in terms of a coupled system in which the brain holds a privileged position. Without our ability to mentally travel in time, we could not foresee future imagined events, and calendars would be useless. Likewise, without metarepresentation the extended mind would not be possible as symbolic storage requires second-order representations. To date, the extended mind hypothesis has mainly been a philosophical construct that has hardly been empirically investigated (but, see e.g., Kirsh, 1996). This has made it difficult to assess how far-reaching the influence of epistemic artefacts on human cognition is. Cognitive science, firmly embedded in archaeology can provide an explanatory framework for elucidating the adaptive advantages of an extended mind.

References

- Antle, M. C., & Silver, R. (2005). Orchestrating time: arrangements of the brain circadian clock. *Trends in Neuroscience*, 28, 145–151.
- Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Science*, 5, 533–539.
- Bateson, M. (2003). Interval timing and optimal foraging. In W.H. Meck (Ed.), *Functional and neural mechanisms of interval timing*. Broca Raton: CRC Press.
- Breuer, T., Ndoundou-Hockembal, M., & Fishlock, V. (2005). First observation of tool use in wild gorillas. *PLoS Biology*, 3, e380.S.
- Call, J., & Tomasello, M. (1999). A nonverbal false belief task: the performance of children and great apes. *Child Development*, 70, 381–395.

- Caspari, R., & Lee, S.-H. (2004). Older age becomes common late in human evolution. *Proceedings of the National Academy of Sciences USA*, *101*, 10895–10900.
- Clark, A., & Chalmers, D. (1998). The extended mind. *Analysis*, *58*, 7–19.
- Clayton, N. S., & Dickinson, A. (1998). Episodic-like memory during cache recovery by scrub jays. *Nature*, *395*, 272–274.
- Day, M. (2004). Religion, off-line cognition and the extended mind. *Journal of Cognition and Culture*, *4*, 101–121.
- De Cruz, H. (2006). Why are some numerical concepts more successful than others? An evolutionary perspective on the history of number concepts. *Evolution and Human Behavior*, *27*, 306–323.
- Dennett, D. (2000). Making tools for thinking. In D. Sperber (Ed.), *Metarepresentation. A multidisciplinary perspective*. New York: Oxford University Press.
- d'Errico, F. (1994). Birds of Cosquer cave. The great auk (*Pinguinus impennis*) and its significance during the Upper Palaeolithic. *Rock Art Research*, *11*, 45–57.
- d'Errico, F. (1998). Palaeolithic origins of artificial memory systems: an evolutionary perspective. In C. Renfrew & C. Scarre (Eds.), *Cognition and material culture: the archaeology of symbolic storage*. Cambridge: McDonald Institute for Archaeological Research.
- Donald, M. (1991). *Origins of the modern mind: three stages in the evolution of culture and cognition*. Cambridge, Ma.: Harvard University Press.
- Ghezzi, I. & Ruggles, C. (2007). Chankillo: a 2300-year-old solar observatory in coastal Peru. *Science*, *315*, 1239–1243.
- Giere, R.N. (2004). The problem of agency in scientific distributed cognitive systems. *Journal of Cognition and Culture*, *4*, 759–774.
- Kirsh, D. (1996). Adapting the environment instead of oneself. *Adaptive Behavior*, *4*, 415–452.
- Klein, R. G., Cruz-Uribe, K., & Skinner, J. (1999). Fur seal bones reveal variability in prehistoric human seasonal movements on the southwest African coast. *Archaeozoologia*, *10*, 181–188.
- Kummer, H. (1995). Causal knowledge in animals. In D. Sperber, D. Premack & A. J. Premack (Eds.), *Causal cognition. A multidisciplinary debate*. Oxford: Clarendon Press.
- Leslie, A.M. (1987). Pretense and representation: the origins of “theory of mind”. *Psychological Review*, *94*, 412–426.
- Marsh, E.J., & Tversky, B. (2004). Spinning the stories of our lives. *Applied Cognitive Psychology*, *18*, 491–503.
- Marshack, A. (1972). Cognitive aspects of Upper Palaeolithic engraving. *Current Anthropology*, *13*, 445–461.
- Marshack, A. (1991). The Tai plaque and calendrical notation in the Upper Palaeolithic. *Cambridge Archaeological Journal*, *1*, 25–61.
- Mithen, S. (1988). Looking and learning: Upper Palaeolithic art and information gathering. *World Archaeology*, *19*, 297–327.
- Mithen, S. (2000). Mind, brain and material culture: an archaeological perspective. In P. Carruthers & A. Chamberlain (Eds.), *Evolution and the human mind. Modularity, language and meta-cognition*. Cambridge: Cambridge University Press.
- Mondragón, C. (2004). Of winds, worms and mana: the traditional calendar of the Torres Islands, Vanuatu. *Oceania*, *74*, 289–308.
- Perner, J., & Ruffman, T. (1995). Episodic memory and auto-noetic consciousness: developmental evidence and a theory of childhood amnesia. *Journal of Experimental Child Psychology*, *59*, 516–546.
- Potts, R. (1994). Variables versus models of early Pleistocene hominid land use. *Journal of Human Evolution*, *27*, 7–24.
- Radcliffe-Brown, A. R. (1922). *The Andaman islanders*. New York: The Free Press of Glencoe.
- Roberts, W. A. (2002). Are animals stuck in time? *Psychological Bulletin*, *128*, 473–489.
- Soffer, O. (1989). The Middle to Upper Palaeolithic transition on the Russian plain. In P. Mellars & C. Stringer (Eds.), *The human revolution. Behavioural and biological perspectives in the origins of modern humans*. Edinburgh: Edinburgh University Press.
- Sterelny K. (2004). Externalism, epistemic artefacts and the extended mind. In R. Schantz (Ed.), *The externalist challenge*. Berlin & New York: Walter de Gruyter.
- Stewart, K.M. (1994). Early hominid utilisation of fish resources and implications for seasonality and behaviour. *Journal of Human Evolution*, *27*, 229–245.
- Suddendorf, T., & Corballis, M. C. (1997). Mental time travel and the evolution of the human mind. *Genetic, Social and General Psychology Monographs*, *123*, 133–167.
- Thompson, C., Barresi, J., & Moore, C. (1997). The development of future-oriented prudence and altruism in preschoolers. *Cognitive Development*, *12*, 199–212.
- Thornton, R. (2003). A report of a new Mandan calendric chart. *Ethnohistory*, *50*, 697–705.
- Tulving, E. (2002). Episodic memory: from mind to brain. *Annual Review of Psychology*, *53*, 1–25.
- Tversky, B., & Marsh, E.J. (2000). Biased retellings of events yield biased memories. *Cognitive Psychology*, *40*, 1–38.
- Vargha-Khadem, F., Gadian, D. G., Watkins, K. E., Connelly, A., Van Paesschen, W., & Mishkin, M. (1997). Differential effects of early hippocampal pathology on episodic and semantic memory. *Science*, *277*, 376–380.